For ALL problems: SHOW ALL WORK TO GET FULL CREDIT

Useful equations and constants

<table>
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<tr>
<th>Electron</th>
<th>Proton</th>
<th>Neutron</th>
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<tbody>
<tr>
<td>( m_e = 9.1093897 \times 10^{-28} ) g</td>
<td>( m_p = 1.673 \times 10^{-24} ) g</td>
<td>( m_n = 1.675 \times 10^{-24} ) g</td>
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<td>( q_e = -1.60 \times 10^{-19} ) C</td>
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1 mole = \( 6.022 \times 10^{23} \) = Avogadro's number
1 amu = \( 1.66054 \times 10^{-24} \) g

DO NOT WRITE IN THESE BLANKS

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TOTAL (100)
1. (2 pts) Which one of the following bases is NOT a known strong base?
   a. Ca(OH)₂ (aq)
   b. Ba(OH)₂ (aq)
   c. KOH (aq)
   d. NaOH (aq)
   e. NH₃ (aq)

2. (2 pts) How many moles of ions are produced in solution by dissociation of 1 mole of NiCl₂·6 H₂O?
   a. 2
   b. 3
   c. 4
   d. 6
   e. 9

3. (2 pts) What is the name of HBrO₂?
   
   bromous acid

4. (2 pts) What is the formula for hydroiodic acid?
   
   HI

5. (3 pts) The oxidation number of sulfur in Na₂S₂O₃, is
   
   +2

6. (3 pts) Which of the following is TRUE?
   a. oxidation is the gain of electrons
   b. the substance oxidized is the reducing agent
   c. oxidation is a decrease in oxidation number
   d. all metal cations are poor oxidizing agents.
   e. all statements are false.
7. (2 pts) In the reaction below, which ions are the spectator ions?

\[ \text{K}_2\text{SO}_4 (aq) + \text{Ba(NO}_3\text{)}_2 (aq) \rightarrow \text{BaSO}_4 (s) + 2 \text{KNO}_3 (aq) \]

a. \( \text{Ba}^{2+} \) and \( \text{SO}_4^{2-} \)

b. \( \text{Ba}^{2+} \) and \( \text{K}^+ \)

c. \( \text{Ba}^{2+} \) and \( \text{NO}_3^- \)

d. \( \text{K}^+ \) and \( \text{SO}_4^{2-} \)

\( \bigcirc \) \( \text{K}^+ \) and \( \text{NO}_3^- \)

8. An unknown compound is composed of C, H and N. The following percent composition is determined experimentally for a 10.00 gram sample of the compound: 74.0% carbon, 8.70% hydrogen, and 17.3% nitrogen.

(a) (6 pts) Determine the number of moles of carbon, hydrogen and nitrogen that are present:

\[
\begin{align*}
7.40 \text{g} \times \frac{12.09}{1} & = 0.616 \\
0.870 \text{g} \times \frac{1 \text{ mole}}{14.0} & = 0.062 \\
1.73 \text{g} \times \frac{1 \text{ mole}}{14.0} & = 0.124
\end{align*}
\]

(b) (4 pts) What is the empirical formula of the unknown compound?

Empirical formula = \( \text{C}_5\text{H}_7\text{N} \)

9. (2 pts) Which one of the following is a nonelectrolyte?

a. aqueous \( \text{Ba(NO}_3\text{)}_2 \) solution

b. aqueous \( \text{CaCl}_2 \) solution

c. aqueous \( \text{Li}_3\text{PO}_4 \) solution

\( \bigcirc \) aqueous \( \text{CH}_3\text{OH} \) solution

e. aqueous \( \text{K}_2\text{SO}_4 \) solution
10. (3 pts) The % nitrogen by mass in urea, \((H_2N)_2CO\), is:

a. 23.3%
b. 31.3%
c. 38.0%
d. 46.7%
e. 60.9%

11. One of the steps in the commercial process for converting ammonia to nitric acid involves the conversion of \(NH_3\) to NO:

\[
4 \text{NH}_3 (g) + 5 \text{O}_2 (g) \rightarrow 4 \text{NO} (g) + 6 \text{H}_2\text{O} (g)
\]

In a certain experiment, 2.50 grams of \(NH_3\) reacts with 2.85 grams of \(O_2\).

(a) (4 pts) How many moles of \(NH_3\) and \(O_2\) are being reacted?

\[
\text{moles } NH_3 = 0.147 \\
\text{moles } O_2 = 0.0891
\]

(b) (2 pts) Which reactant is the limiting reactant?

Limiting reactant = \(O_2\)

12. (3 pts) Write a balanced molecular equation for the following reaction (using chemical formulas):

\([\text{chromium(III) hydroxide}] + [\text{perchloric acid}] \rightarrow [\text{chromium(III) perchlorate}] + [\text{water}]\)

Balanced reaction: \(\text{Cr(OH)}_3 + 3\text{HClO}_4 \rightarrow \text{Cr(ClO}_4)_3 + 3\text{H}_2\text{O}\)

13. (3 pts) The empirical formula of a group of compounds is CHCl. Lindane, a powerful insecticide, is a member of this group. The molecular mass of lindane is 290.8 g mol\(^{-1}\). What is the molecular formula of lindane?

a. CHCl  b. \(C_2H_2Cl_2\)  c. \(C_4H_4Cl_4\)  d. \(C_6H_6Cl_6\)  e. \(C_8H_8Cl_8\)
14. (4 pts) Consider the fermentation reaction of glucose by yeast:

\[
\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2 \text{C}_2\text{H}_5\text{OH} + 2 \text{CO}_2
\]

A 1.00 mole sample of C\(_6\)H\(_{12}\)O\(_6\) was placed in a vat with an excess of yeast. If 46.0 grams of C\(_2\)H\(_5\)OH (molecular mass = 46.068 g mol\(^{-1}\)) was obtained, what is the % yield of C\(_2\)H\(_5\)OH?

a. 100. %
b. 56.0 %
c. 42.0 %
d. 50.0 %
e. 46.0 %

15. (3 pts) Balance the following reaction (enter correct coefficients in the blanks):

\[
\frac{1}{3} \text{H}_2\text{SnCl}_6 + 2 \text{H}_2\text{S} \rightarrow \frac{1}{6} \text{SnS}_2 + 6 \text{HCl}
\]

16. (2 pts) The following reaction is an example of

\[
\text{BaCl}_2 (\text{aq}) + \text{H}_2\text{SO}_4 (\text{aq}) \rightarrow \text{BaSO}_4 (\text{s}) + 2 \text{HCl (aq)}
\]

a. an ionic redox reaction
b. an ionic acid-base neutralization reaction
c. a molecular acid-base neutralization reaction
d. a molecular precipitation reaction
e. a molecular redox reaction

17. (3 pts) In the reaction shown below, what species is being reduced?

\[
2 \text{LiBr} + \text{Cl}_2 \rightarrow 2 \text{LiCl} + \text{Br}_2
\]

a. Li\(^+\) b. Br\(^-\) c. Cl\(^-\) d. Br\(_2\) e. Cl\(_2\)
18. (2 pts) Which one of the following compounds is soluble in water?
   a. NiCO₃
   b. PbSO₄
   c. BaCl₂
   d. AgCl
   e. Fe(OH)₃

19. (5 pts) Sodium acetate, NaC₂H₃O₂, has a formula mass of 82.034 g mol⁻¹. What is the molar concentration of a solution prepared by dissolving 4.10 grams of sodium acetate in enough water to prepare 250.0 mL of the solution?
   a. 0.200 molar
   b. 1.025 molar
   c. 1.345 molar
   d. 2.00 x 10⁻⁴ molar
   e. 16.4 molar

20. (4 pts) Using the activity series, determine whether each of the following reactions will occur. If a reaction occurs, write the products; if no reaction occurs, write "NO REACTION".
   a. Sr + Mg²⁺ \rightarrow Sr^{2+} + Mg
   b. Co + Hg²⁺ \rightarrow Hg + Co²⁺

21. (6 pts) Lactic acid, (HC₃H₅O₃), is a monoprotic acid that forms when milk becomes sour. In one laboratory exercise for students taking a food chemistry course, a 40.00 mL sample of an aqueous lactic acid solution required 26.50 mL of 0.140 molar NaOH (aq) to neutralize it during the course of a titration. From this data, what is the molar concentration of lactic acid in the solution?
   a. 0.0928 molar
   b. 0.148 molar
   c. 0.211 molar
   d. 0.757 molar
   e. 0.928 molar
22. (4 pts) Write the net ionic equation for the reactions which occur upon mixing the following substances:

(a) \( \text{HClO}_4 \text{(aq)} + \text{Ba(OH)}_2 \text{(aq)} \rightarrow \)

\[
\text{H}^+ \text{(aq)} + \text{OH}^- \text{(aq)} \rightarrow \text{H}_2\text{O(l)}
\]

(b) \( \text{Na}_2\text{CO}_3 \text{(aq)} + \text{HNO}_3 \text{(aq)} \rightarrow \)

\[
2\text{H}^+ \text{(aq)} + \text{CO}_3^{2-} \text{(aq)} \rightarrow \text{H}_2\text{O(l)} + \text{CO}_2 \text{(g)}
\]

23. (3 pts) An aqueous solution contains one solute which is either sodium acetate, sodium sulfate, or potassium nitrate. Addition of some barium chloride to a sample of the solution caused the formation of a white precipitate. Which of the three possibilities was the solute (write the chemical formula)?

Sodium Sulfate

24. (3 pts) Which of the following is an oxidation/reduction reaction?

a. \( 2 \text{Al} \text{(s)} + 3 \text{Br}_2 \text{(l)} \rightarrow 2 \text{AlBr}_3 \text{(l)} \)

b. \( \text{CaCO}_3 \text{(s)} \rightarrow \text{CO}_2 \text{(g)} + \text{CaO} \text{(s)} \)

c. \( \text{NiCl}_2 \text{(aq)} + 2 \text{AgNO}_3 \text{(aq)} \rightarrow 2 \text{AgCl} \text{(s)} + \text{Ni(NO}_3)_2 \text{(aq)} \)

d. all of the above

e. none of the above

25. (4 pts) Predict the products and write the balanced molecular equation for the following reaction.

\( 2 \text{HCl} \text{(aq)} + \text{Mg} \text{(s)} \rightarrow \)

\( \text{MgCl}_2 \text{(aq)} + \text{H}_2 \text{(g)} \)

26. (2 pts) A dynamic equilibrium is reached when acetic acid is dissolved in water. Which of the species shown below is present in the largest amount in solution?

a. \( \text{C}_2\text{H}_3\text{O}_2^- \text{(aq)} \)

b. \( \text{H}^+ \text{(aq)} \)

c. \( \text{HC}_2\text{H}_3\text{O}_2 \text{(aq)} \)

d. \( \text{H}_3\text{O}^+ \text{(aq)} \)

e. \( \text{OH}^- \text{(aq)} \)
27. For the following oxidation-reduction (redox) reaction which occurs in acidic solution:

\[ \text{I}^- + \text{NO}_3^- \rightarrow \text{NO}_2^- + \text{IO}_3^- \]

a. (3 pts) Write the balanced oxidation half-reaction

\[ 3\text{H}_2\text{O} + \text{I}^- \rightarrow \text{IO}_3^- + 6\text{H}^+ + 6\text{e}^- \]

b. (3 pts) Write the balanced reduction half-reaction

\[ 2\text{H}^+ + \text{NO}_3^- + \text{e}^- \rightarrow \text{NO}_2^- + \text{H}_2\text{O} \]

c. (3 pts) Write the overall balanced equation

\[ 3\text{H}_2\text{O} + 12\text{H}^+ + \text{I}^- + 6\text{NO}_3^- \rightarrow \text{IO}_3^- + 6\text{H}^+ + 6\text{NO}_2^- + 6\text{H}_2\text{O} \]

\[ (6\text{H}^+ + \text{I}^- + 6\text{NO}_3^- \rightarrow \text{IO}_3^- + 6\text{NO}_2^- + 3\text{H}_2\text{O}) \]

d. (3 pts) Name the reducing agent

\[ \text{I}^- \]